NUC TP 304

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HARDWARE DEVELOPMENT FOR PROJECT QUICK FIND, THE SEA LION OBJECT RECOVERY SYSTEM

by

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Ocean Technology Department

July 1972

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13. ABSTRACT

The hardware program for Project Quick Find involved the development of a variety of training devices, grabber recovery units, and other related hardware. This report describes the development, test, and evaluation of a sea lion nose-carried grabber device used to effect the recovery of bottom-sitting test ordnance. The primary grabber developed was deployed by a sea lion against a Fleet-fired ASROC missile and was instrumental in its recovery, unassisted by diver personnel.

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SUMMARY

Objective

Project Quick Find is a recovery system that consists of two men, a rubber boat, a reel of nylon line, a pinger receiver, a grabber device, and a California sea lion. This report documents the development of the animal-carried recovery device and associated training and practice hardware.

Results

A nose-carried grabber device was developed which could be operated by a sea lion. The device has an in-air weight of 3 pounds 12 ounces and a seawater weight of 1 pound 2 ounces. The grabber and recovery line used to raise a sunken object are capable of lifting 2000 pounds.

Recommendation

A family of grabber devices should be developed to extend the capability of the Quick Find system by permitting the recovery of a variety of underwater objects.

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INTRODUCTION

This report documents some of the hardware development for Project Quick Find, a sea lion object recovery system. The primary emphasis for development was placed on a grabber recovery mechanism that was to be carried by a sea lion and placed on a recovery target. The target was then to be brought to the surface by the grabber, either by an attached line or by a built-in buoyant lift system.

Other devices and training aids that were designed and fabricated for this program were:

1. Attachment devices (animal nose cups) for the attachment of hardware to a sea lion

2. Target

3. Animal recovery and tracking unit

One of the most important findings to come out of this effort, given the feasibility demonstrated by the Quick Find Project to recover an ASROC depth charge, is the desirability of having available a family of grabbers that can be used by marine mammals to recover a variety of objects of different shapes and sizes. Although the Quick Find system provides a useful recovery capability, it can be extended significantly through the development of grabbers for the recovery of other targets.

This report will first give a brief description of the Quick Find recovery system, then a more comprehensive recounting of the hardware development, next a discussion of the results of the recovery system operational demonstration, and finally a set of recommendations for the development of hardware for future mammal recovery systems. Assembly drawings of the final system hardware appear in Appendix A, and grabber reliability and load tests are contained in Appendix B.

QUICK FIND RECOVERY SYSTEM

In its final form Quick Find consists of two men, a rubber boat, a reel of nylon line, a pinger–receiver, a grabber, and a California sea lion.* It evolved, after considerable investigation, to the following operational concept, which is illustrated in Fig. 1. The sea lion is transported to the recovery area in cages on the deck of the primary recovery vessel. When a pinger has been detected by listening gear, or when it has otherwise been determined that the recovery vessel is in the target area, a rubber raft containing the sea lion and two handlers is lowered into the water. Conditioned to report the presence of a 9-kHz pinger, the animal, after being released into the water, systematically searches the area. If he hears the pinger, he gets out of the water and into the rubber boat, and signals his find by pressing a rubber pad. A recovery line is attached to a combination marker and object-grabbing device that is then placed on the sea lion. The sea lion reenters the water and dives to the pingered object. He attaches the grabber to the object and returns to the recovery boat. The surface end of the recovery line is then used to retrieve the object.

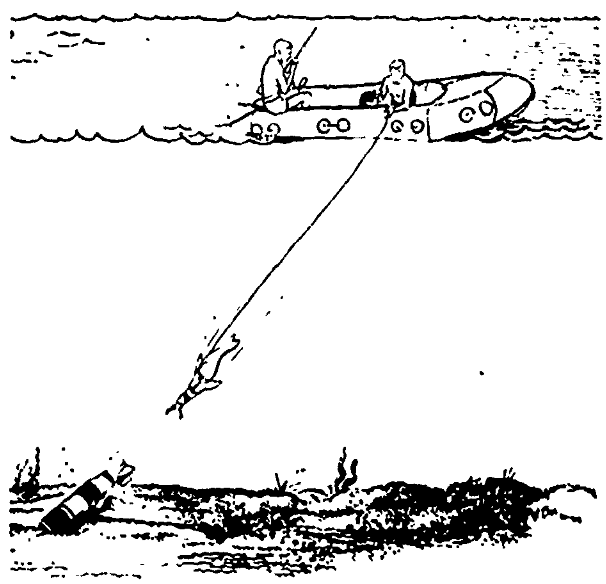

Figure 1. Quick Find operational concept.

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* Naval Undersea Research and Development Center, San Diego. Project Quick Find: a marine mammal system for object recovery, by Martin E. Conboy. June 1972. (NUC TP 268, Rev. 1.)

DESCRIPTION OF HARDWARE

Grabbers

A sea-lion-operated grabber mechanism was designed for the Quick Find recovery program. The sea lion was to attach the grabber to the target, which was subsequently to be hauled to the surface and recovered. This grabber unit was to be lightweight, no greater than 3 pounds in water, and one that could be easily carried and operated by the sea lion. The grabber's shape, weight, and center of gravity were to allow as much free movement as possible during his search. The final unit was to be able to lift a maximum of 2000 pounds.

The grabber unit was in development approximately 1 year, beginning in December 1969. During this period, over 4 months were spent in designing training aid hardware. These aids were essential for the final grabber system design.

Training Grabbers. Many training grabbers were necessary in order to examine the animal's capabilities. The weight and relative size of the attachment and recovery devices the animal could handle had to be determined first. It was then necessary to determine how the animal would react to functional units (such as spring-loaded arms). It was normal for the animal to reject the devices during his first association. Therefore, each of the animals had to be given ample time with the devices before his adaptability could be determined. The devices, given serial numbers for purposes of differentiation, were:

1. M/GD3: A muzzle cup with a nose release button to train the animal to operate a release mechanism (Fig. 2).

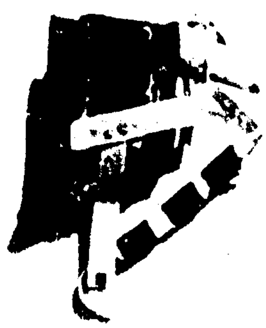


Figure 2. M/GD3 muzzle cup with nose release button.

2. M/GD4. Same as the M/GD3, with the addition of arms for 90-degree coverage of a 22-inch-diameter target (Fig. 3).

3. M/GD4a: Same as the M/GD4, with the addition of two nonmovable grabber arms attached for weight and shape evaluation and animal familiarization.

4. M/GD5a: The first movable spring-loaded, swing-arm grabber, designed to attach to a 22-inch-diameter target (Fig. 4)

5. M/GD5b: A stainless tubular lightweight version of the M/GD5a, proved to be too fragile for extended training purposes (Fig. 5).

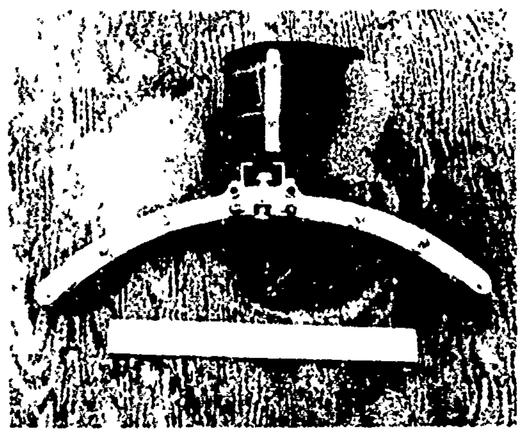


Figure 3. M/GD4 muzzle cup with arms for 90-degree coverage of 22-inch-diameter target.

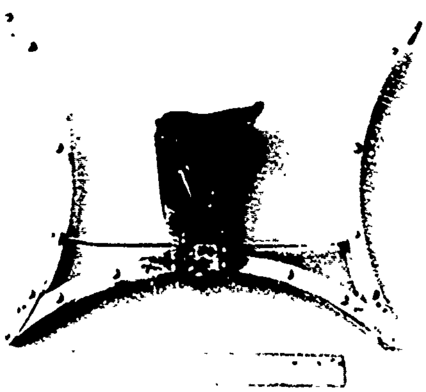


Figure 4. M/GD5a movable spring-loaded swing-arm grabber.

Figure 5. M/GD5b stainless tubular lightweight grabber.

6. M/GD5c: A refined version of the M/GD5a grabber. This unit proved very satisfactory, and six were made for training purposes (Fig. 6). A float-release mechanism was later incorporated to enable retrieval without a surface line or divers (Fig. 7 and 8). The float device proved complicated and unreliable, and the concept as well as the device was dropped.

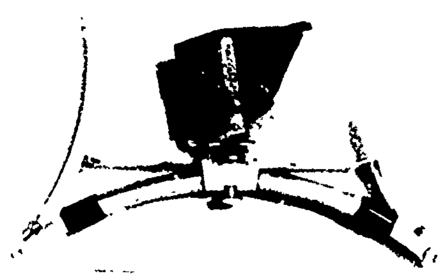


Figure 6. M/GD5c grabber, a refined version of the M/GD5a grabber.

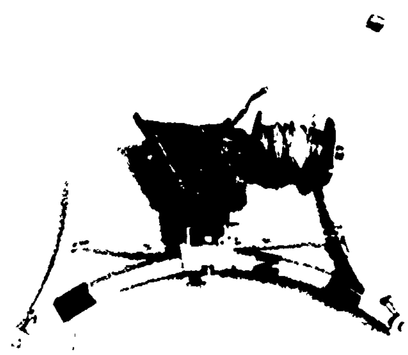


Figure 7. M/GD5c grabber with a float-release mechanism.

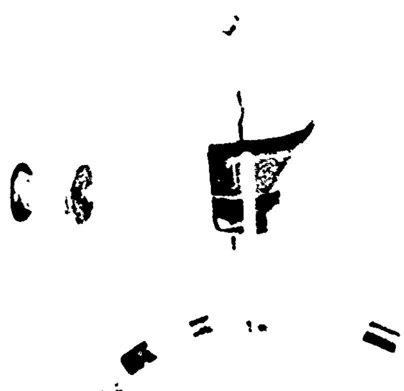


Figure 8. Fired M/GD5c grabber with spool float.

7. M/GD6: A M/GD5 grabber was modified to fit a 12-inch-diameter target. Note automatic detaching nose cup (Fig. 9). This design modification proved satisfactory, and four additional units were fabricated. This training device is presently being used with the G-7, a nondetachable nose cup (Fig. 10). Figure 11 shows a sea lion wearing the M/GD6 grabber during a training session.

Figure 9 M/GD6 grabber in fired position

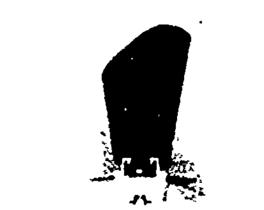


Figure 10. M/GD6 grabber with G-7 series nose cup.

Figure 11. Sea lion wearing M/GD6 training aid grabber during training session.

Operational Grabber. The final design did not begin until May 1970, when the target was specified. In April design began for a grabbing device with a telescopic arm to lift the target. This design was discontinued when it was decided that the grabber system had to recover a variety of objects having diameters ranging from 18 inches to 22 inches. A multidiameter swing-arm grabber design was then attempted. A series of stress calculations were made to evaluate grabber load capabilities. These calculations were then substantiated by actual load and reliability tests (Appendix B). This design effort was stopped due to target training problems with the sea lion. After reevaluation, the target was patterned after the 12-inch-diameter ASROC depth charge, and development was resumed on a grabber utilizing the telescopic arm concept. This grabber design was designated as the G-7 series and consisted of the following models:

1. G-7A: This model was designed to test the tracking arm concept. Although the pin method proved unsatisfactory, the design concept proved feasible. The G-7A, shown in Fig. 12, was used as an experimental model for weight and drag tests. It was also occasionally used as a training device.

2. G-7B: This grabber was designed for a Mk 56 depth bomb, a 13¾-inch-diameter target. The binding problems in the G-7A were solved by making a solid tee and track to guide the arms. The tee was made as part of the arms, with corresponding track in the body. Although tolerances were a problem, this method was very successful. The G-7B was used as a backup grabber for the final test and evaluation and was damaged beyond repair during that test.

Figure 12. G-7a grabber modified for weight and drag tests.

3. G-7C1: This model was designed for the 12-inch-diameter target and used the tee track method as in the G-7B. This grabber was successfully used in a recovery of an ASROC depth charge in November 1970 (Fig. 13 and 14).

4. G-7C2: This grabber is identical to the G-7C1, except for the addition of a head light.

5. G-7D: This grabber was an improvement over the G-7C design; the body plates were eliminated and the entire tee groove was cut in the body itself. The body in the G-7D was also cut with tapered sides so that the arms would meet when fired. Previous models had parallel arms that when fired were offset the thickness of the body. The arms were also designed so that a minimum sliding surface was exposed (Fig. 15).

The grabber that was finally used (Fig. 13) consists of an aluminum body with two sliding arms which are powered by clock-wound springs mounted on the body.

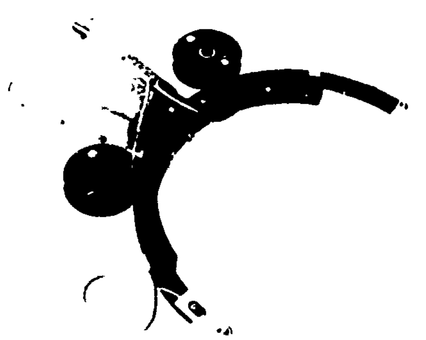


Figure 13. G-7C1 grabber in cocked position.

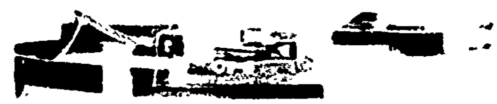


Figure 14. G-7C grabber latch in locked position.

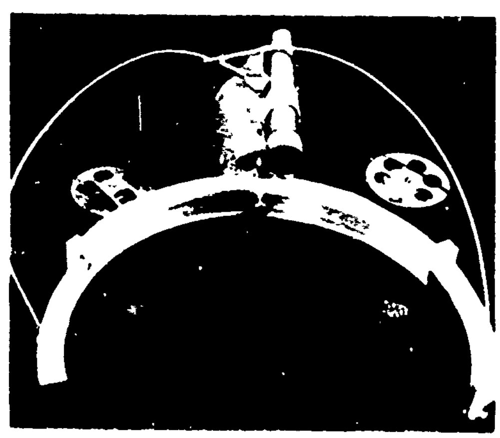


Figure 15. G-7D grabber.

A simple release button mechanism triggers the arms. The sea lion is trained to place the grabber on the tapered aft section of the target, just forward of the tail fins. When the sea lion strikes the target with the grabber, the trigger release mechanism is activated and the telescopic slide arms are deployed. A solid tee and track enable the arms to encircle the target. The tee is made as part of the arms, and the track is in the body. A stainless steel cable is attached to each arm and is used to lift the target. As the arms fire around the target and come together on the other side, a latch locks the two cables together, completing a noose around the target. The target can then be hauled to the surface by an attached nylon line.

All parts for the grabber were fabricated at NUC, Hawaii. A special anodizing Teflon coating was applied to all aluminum parts for corrosion resistance and friction reduction. The trigger release mechanism and the latch were made of stainless steel for the required strength and durability. All other metal parts were constructed from 6061 aluminum. The nose cup was made of a rubber compound, but all other nonmetallic parts were made of buoyant materials. Stainless steel springs were specially designed for the grabber. Aircraft cables were used for the cable assembly and were joined on the grabber after it was assembled.

The specifications for the G-7C grabber are:

Weight: The grabber weight in air is 3 pounds 12 ounces, in salt water 1 pound 2 ounces.

Load limits: Maximum 2000 pounds.

Size: Maximum thickness is 5 inches at nose cup; maximum width is 14 inches; maximum length is 20 inches (extended arms).

Firing speed: The time elapsed from actuation of the trigger to latching of the cables is 0.5 to 1.0 second.

Nose Cups

The interphase between the mechanical lifting device and the animal was a difficult problem. The device, a nose cup, had to be stable on the animal and yet be comfortable for him to carry. Different animal sizes compounded the problem, since it was not desirable to design separate devices for each animal. Many marine mammal nose cups have been designed for different types of applications. Some of these nose cups include: machined syntactic foam fitted with neoprene rubber, fiberglass molds lined with neoprene for proper fitting, and nylon neoprene sewn to fit. The sewn nylon neoprene was used for the initial sea lion nose cup and attachment. This type of nose cup had to be reinforced with metal bands in order to attach the necessary training devices. It was difficult to work with and not very

durable. A flexible but firm rubber molding compound (polyurethane) was cast in a specially fabricated mold. This rubber nose cup (shown in Fig. 10) is multifitting, lightweight, durable, firm fitting, and easy to use. It is a significant improvement over past nose cups.

Target

A training target was developed for the Quick Find recovery system. This target simulates an actual target stuck upright in the bottom. The target was designed to allow numerous training cycles each day, without the necessity of cables, lines, or divers. When target recovery is desired, the surface control transmits a signal to the target unit which releases a small buoy. This buoy comes to the surface carrying with it a small line which can be hauled in until the main buoyant lifting line reaches the surface. The entire target system can be retrieved by the buoyant line.

The training target is shown in Fig. 16 at sea aboard the ocean work barge. The tapered portion of the target, dark area between the tail fins and the cylindrical tube section, is sound-isolated from the rest of the target. This section is also a pressure hull and reduces the target's in-water weight. The modified tail cone is attached to a fabricated aluminum cylinder mounted on a base plate. The tail cone, mid-body cylinder, and base plate is a unit for easy assembly and disassembly. The 6-foot-square frame creates a steady platform and ensures an upright position when being lowered to the bottom. A pelican hook, operated from the surface, releases the lowering bridle from the four corners of the frame, leaving the target sitting on the bottom without lines going to the surface.

The sensitive portion of the target is the attachment zone for the animals. This section houses a klunk (hit) detector which is used to indicate that the sea lion has attempted his attachment at the desired area of the target. When a proper hit occurs, the noise made during the attachment turns off the pinger and signals the surface of

Figure 16. Sea lion training target.

a successful training trial. Additionally, the training device release trip is examined upon recovery to verify proper animal usage.

In addition to the klunk detector, the target houses a command receiver. The acoustic command transmitter–receiver system, including all pingers, klunk detectors, and release mechanisms, was procured from InterOcean Systems, Inc., of San Diego. The remaining target hardware was fabricated by NUC, Hawaii. This system worked satisfactorily down to about 150 feet. At greater depths, the klunk detectors were too erratic to be dependable, either actuating without a hit occuring or failing to actuate even with heavy blows. Considerable trouble was also encountered with the system's underwater connectors. This problem was so severe that the trainers devised other methods to train their animals in deeper water. They continued to use the same target, however, but did not rely upon the acoustic command system for proper hit data and target recovery.

Recovery and Tracking Unit

During open-ocean training of marine mammals there always exists the possibility of the animal escaping. Tending lines are not always feasible and can often become impractical for certain training functions. Therefore, a device was needed to help locate an escaping animal or possibly aid in his recovery.* A carbon dioxide automatically activated float was designed and fabricated for a marine mammal locating and restraining device (Fig. 17). This float is timed by a magnesium washer which after approximately 35 minutes (plus or minus 10% accuracy) will release a spring-loaded plunger. The plunger strikes the carbon dioxide cartridge, and the escaping gas inflates the housed balloon. The balloon acts as a marker to locate the animal and as a restraining device to keep him on the surface for recovery. The device weighs less than 6 ounces and is 6 inches long and 1 inch in diameter.

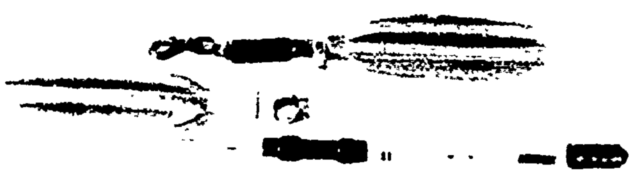


Figure 17. Sea lion float device, assembled and disassembled.

* Naval Undersea Research and Development Center, San Diego. Sea lion recovery float, by S. H. Ridgway. April 1969. (NUWC TP 134.)

QUICK FIND OPERATIONAL TEST

The entire sea lion recovery system was tested during an actual ASROC test shot November 5 and 6 at San Nicolas Island, California. Three sea lions, their necessary equipment, and a team of four animal handlers were transported by commercial air to San Nicolas Island. There the system was placed aboard the primary recovery craft, a YFU, on the morning of November 5.

The actual shot was fired from a Navy destroyer but was delayed until approximately 1600 due to fire control problems. After firing, foggy conditions hampered the target location, and it was almost dark before the first recovery with the Quick Find system was attempted. After several unsuccessful attempts (grabber placement on the target was not accomplished), darkness forced the recovery to be aborted.

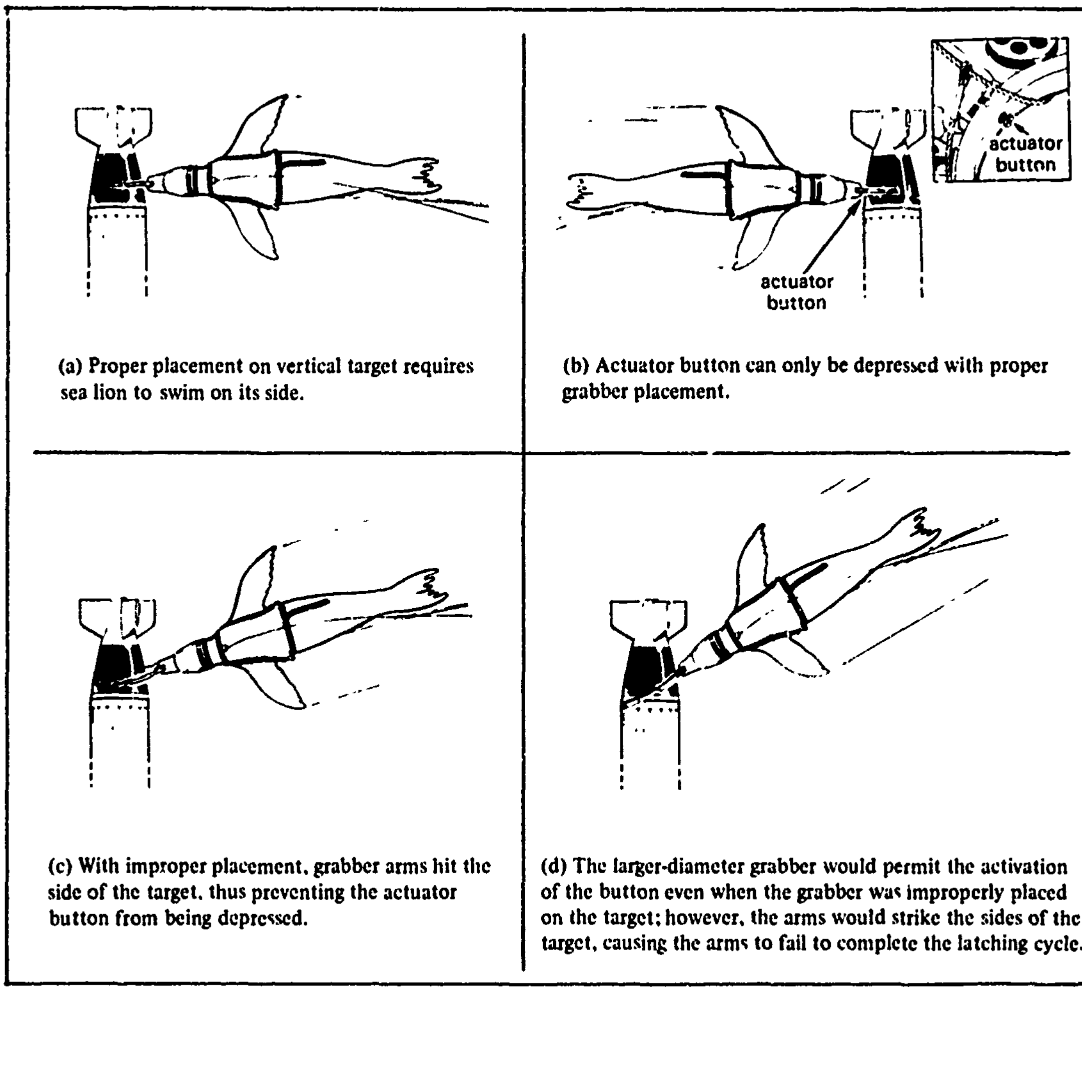
The following day, target location was again slowed by limited surface visibility, and relocation was not effected until 1200. Several recovery attempts were made, but again the grabber device was not successfully deployed. After an hour, during which time each of the three animals was deployed unsuccessfully, a diver was sent to visually check the target. The target was found to be in a nearly vertical position and embedded approximately 3 feet in the bottom. The vertical position of the target probably was the cause for the unsuccessful attempts by the animals. The animals had not been trained to place the grabber on a vertical target. It was also found that the target had not been properly painted and did not offer the necessary clues for the animals to use in determining where to place the grabber.

The vertical target position would make it necessary for the sea lion to turn completely on its side to place the grabber (Fig. 18a). The diameter of the G-7C grabber mechanism was purposely designed so that the grabber unit would not deploy if it were placed incorrectly on the target. In order for the grabber to deploy it must be placed flush against the tapered section of the target (Fig. 18b). But though the sea lion was hitting the target, the actuator button at the base of the grabber (required to move only a few thousandths of an inch to deploy the arms) was not touching the target (Fig. 18c).

It was decided to use a grabber unit (G-7B) which was designed for a larger target diameter. Due to the larger diameter, the G-7B grabber would deploy even if it were placed incorrectly on the target (Fig. 18d). However, if it were placed on the target at an angle, the arms would strike the target cylinder, fail to make a complete circumference, and fail to lock. This was demonstrated during numerous G-7 grabber test trials. Locking failure would cause the aluminum arms to carry the full lifting load. Previous tests showed that the aluminum arms would fail at a maximum load of 350 pounds.

During the operational test, the arms failed. Examination of the grabber on the

Figure 18. Grabber placement on vertical target.



(a) Proper placement on vertical target requires sea lion to swim on its side.

(b) Actuator button can only be depressed with proper grabber placement.

(c) With improper placement, grabber arms hit the side of the target, thus preventing the actuator button from being depressed.

(d) The larger-diameter grabber would permit the activation of the button even when the grabber was improperly placed on the target; however, the arms would strike the sides of the target, causing the arms to fail to complete the latching cycle.

surface revealed that the arms failed to lock together and were bent and twisted from carrying the total load. It was then decided to try the G-7C grabber one more time. This time, the first attempt by a sea lion was successful. Due to low fuel conditions on the YFU, it was decided to manually place a safety line on the target, utilizing the grabber line to guide the diver's descent. After the line had been placed on the target, the target was successfully hauled to the surface by a Bay City crane.

using only the grabber and line attached by the animal (Fig. 19). The divers observed that the target had been pulled over by the larger-diameter grabber so that it was at an acute angle from the bottom.

Figure 19. ASROC target recovered during Quick Find operational test.

Foul weather, target position, improper target painting, darkness, and successive days of recovery attempts were all detrimental factors in the recovery operation. In spite of these factors, the Quick Find recovery must be considered a success, proving the practicality of this method of object recovery.

RECOMMENDATIONS

1. Experiments should be performed with the sea lion wearing the grabber parallel to its normal swimming position.

2. A grabber or family of grabbers is needed that can be used by different marine mammals to recover objects of different shapes and sizes. To enable these grabbers to be attached to different mammal nose cups, it will be necessary to develop a universal fitting.

3. Other recovery systems should be investigated. During the Quick Find hardware development, recovery methods employing such devices as exploding throw nets, hooks, explosive welds and studs, and flexible rubber fingers were investigated and appeared promising.

Appendix A

HARDWARE ASSEMBLY DRAWINGS

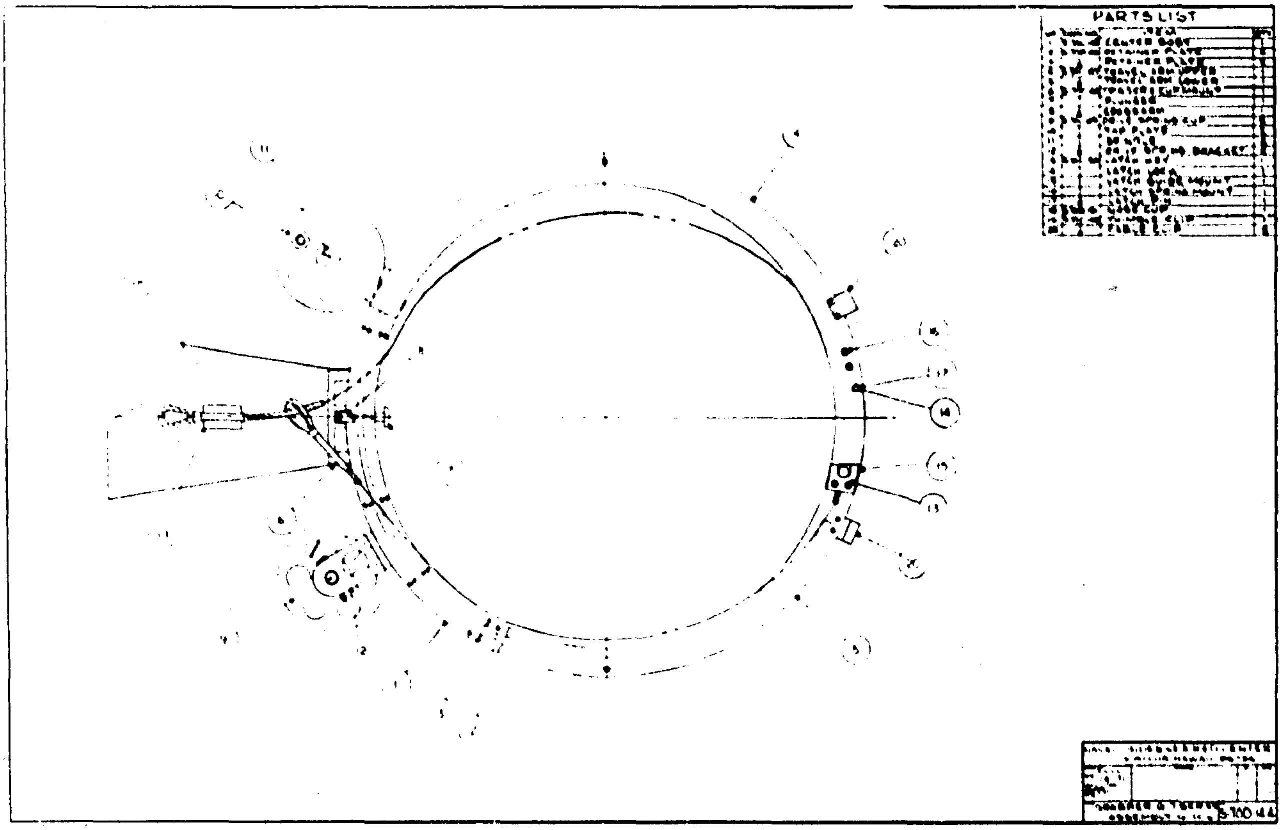


Figure A-1. G-7C grabber assembly.

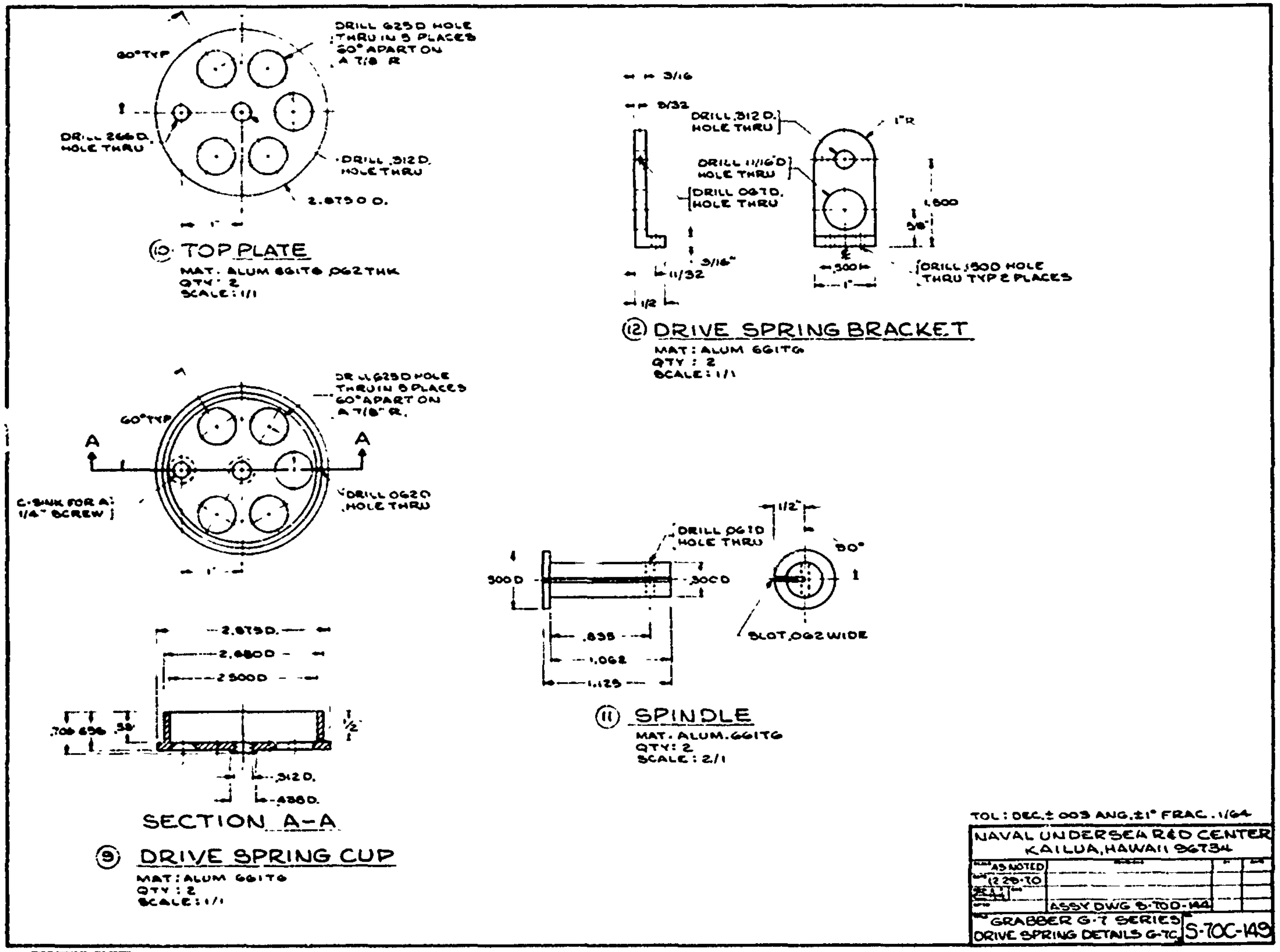


Figure A-2. G-7C grabber, drive spring details.

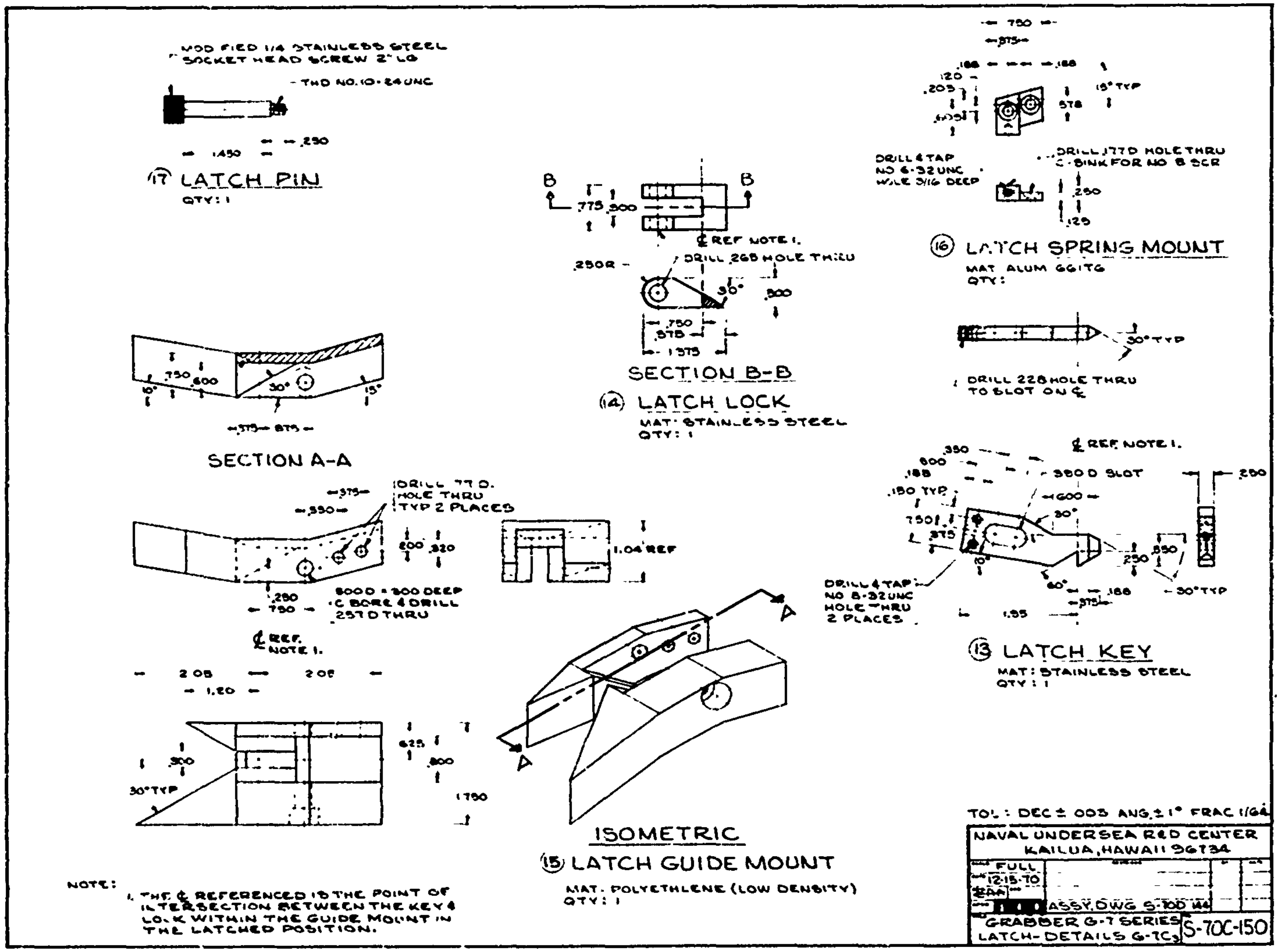


Figure A-3. G-7C grabber series, latch details.

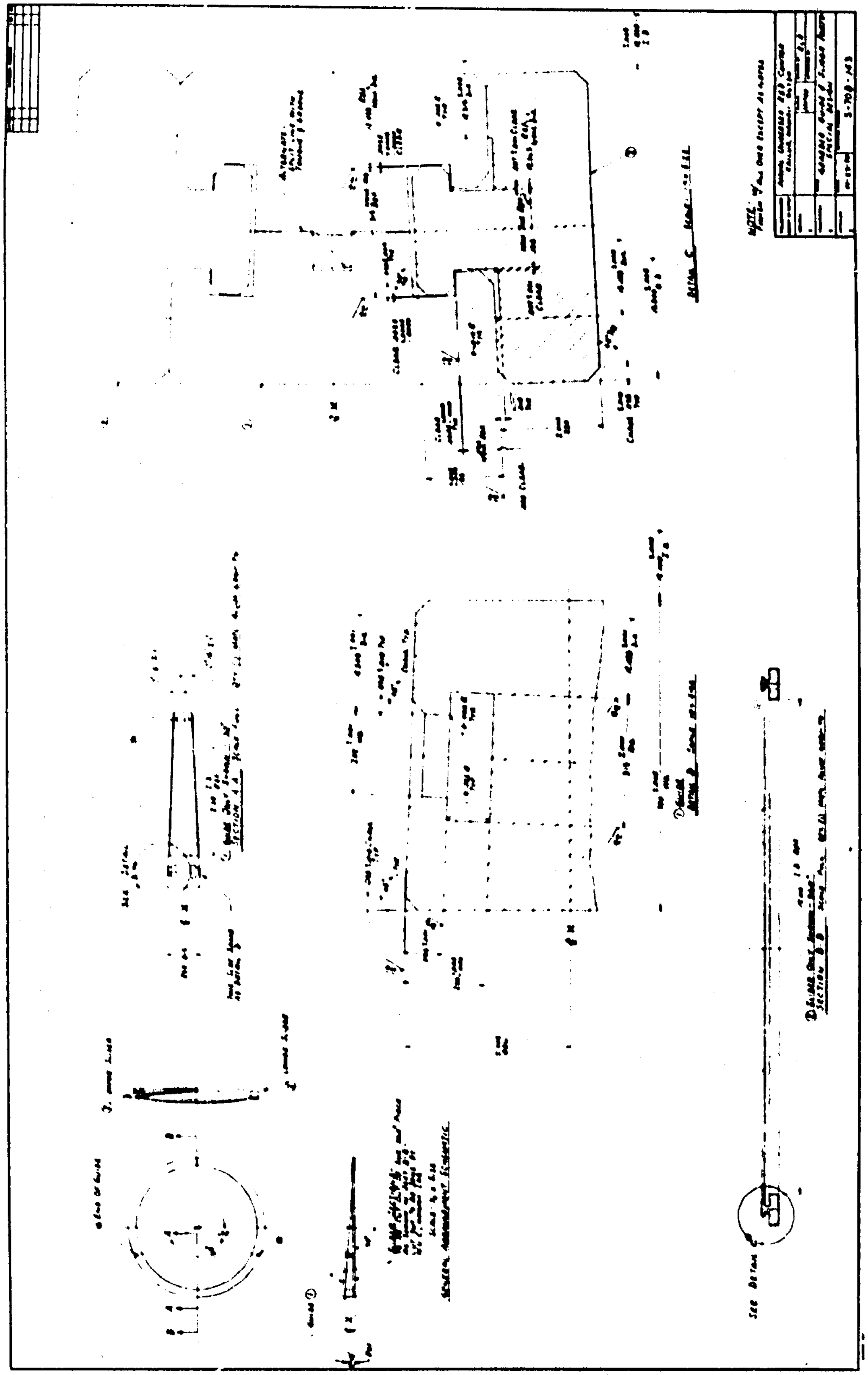


Figure A-4. G-7D grabber guide (special design).

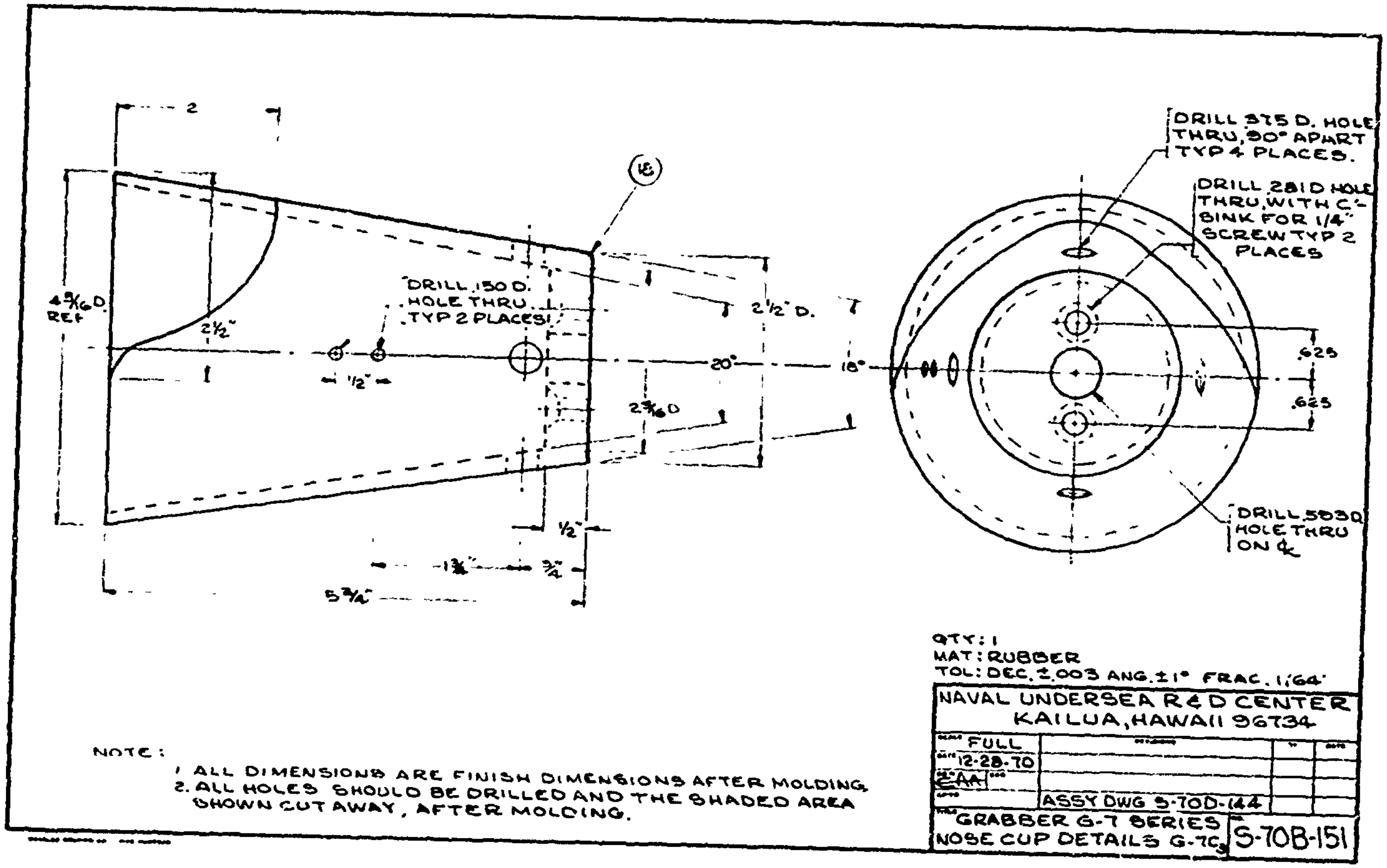


Figure A-5. G-7 nose cup details.

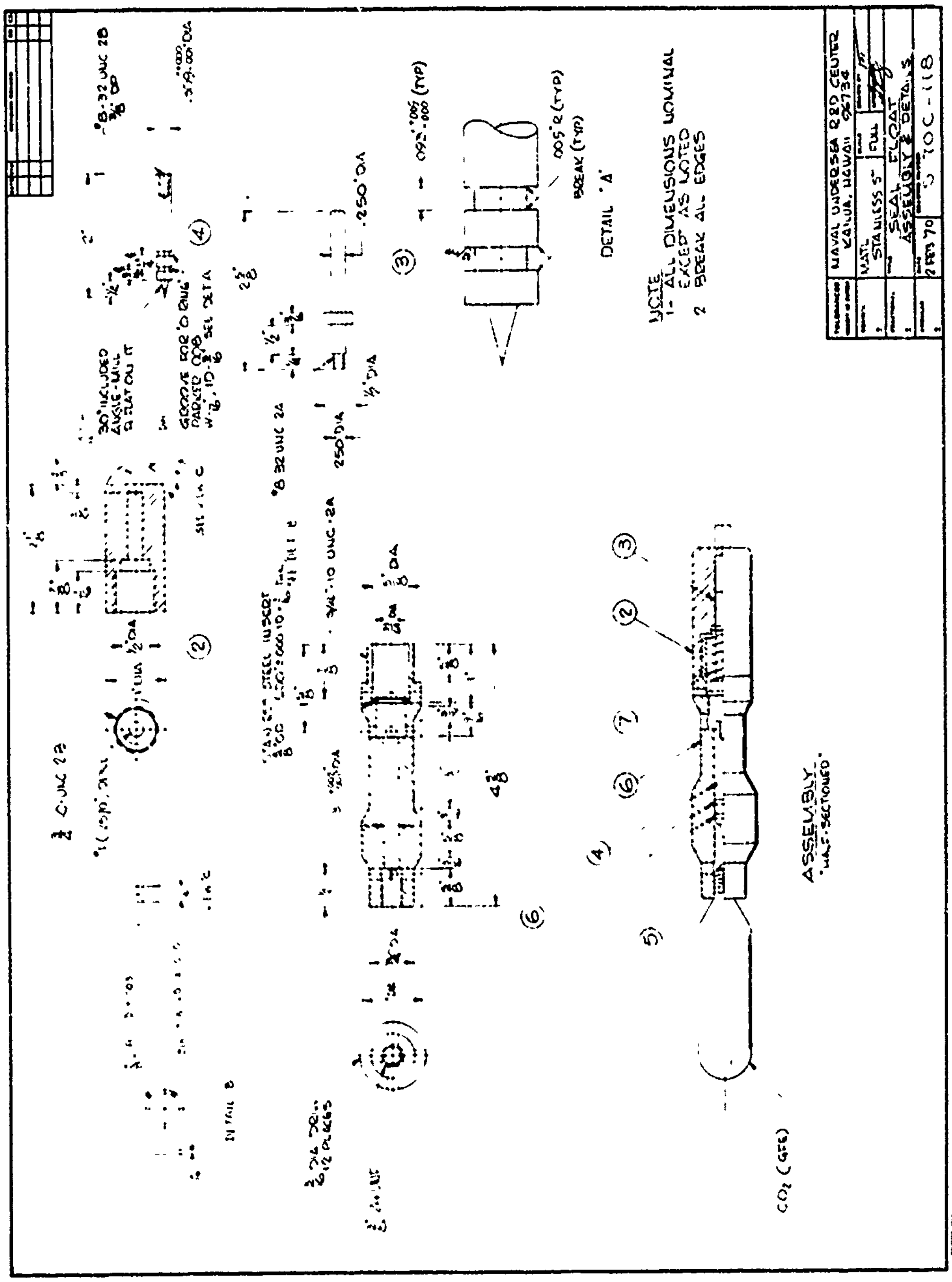


Figure A-6. Float, assembly and details.

Appendix B

GRABBER LOAD AND RELIABILITY TESTS

A series or reliability tests were conducted on the G-7B and G-7C grabbers (Table B-1, B-2, and B-3). These tests involved many different controlled conditions in order to best analyze the grabber's dependability under varying situations. The grabbers were held and struck against the side of a dummy target. Various strike angles were tested. The 45-degree angle of contact proved to be the maximum angle at which the trigger would release and give proper closure at the tapered end of the target. Various strike forces were also tested. During the tests, the cable configurations were changed several times until the ideal configuration was found. The grabber was oiled after approximately 30 repeated firing cycles. Later, portions of the test procedures were performed underwater. A cycle of strike, release, closure, cock, and strike was repeated 122 times. The 122 test cycles were made with 97.5% satisfactory firings. The unsatisfactory firings were due to improper cable configuration, which bound the arm movement, and to a strike angle greater than 45 degrees.

A load test was also made to obtain the load limitations of the cable and latch. The load test was conducted as shown in Fig. B-1. Three load tests were conducted. Test 1 and 2 were made using 1/8-inch-diameter cables made up in a noose configuration. The cable broke in both tests at approximately 1700 pounds. It was determined that the sharp angle produced by passing one cable through a thimble eye reduced the lifting force of that cable, rated at 2000 pounds. Therefore, a 5/32-inch-diameter cable was substituted for the cable passing through the thimble. In test 3 the maximum lifting force of 2000 pounds was reached. In all tests, the latch mechanism showed no signs of strain.

Table B-1. Reliability test record of the G-7B grabber.

Test No.	Angle	Remarks	Conclusion	Test No.	Angle	Remarks	Conclusion
1	right		satisfactory	26	right		satisfactory
2	right		satisfactory	27	right		satisfactory
3	45 deg.		satisfactory	28	right		satisfactory
4	right		satisfactory	29	right		satisfactory
5	right		satisfactory	30	right		satisfactory
6	45 deg.		satisfactory	31	45 deg.		satisfactory
7	right	changed cable config.	satisfactory	32	10 deg.		satisfactory
8	45 deg.	changed cable config.	satisfactory	33	45 deg.	single fire	satisfactory
9	right	changed cable config.	satisfactory	34	right	oiled grabber	satisfactory
10	right	changed cable config.	satisfactory	35	right		satisfactory
11	right	changed cable config.	satisfactory	36	right		satisfactory
12	right	changed cable config.	satisfactory	37	right		satisfactory
13	right	changed cable config.	satisfactory	38	right		satisfactory
14	right	drop test	satisfactory	39	right		satisfactory
15	45 deg.		satisfactory	40	5 deg.		satisfactory
16	right	drop test	satisfactory	41	45 deg.		satisfactory
17	right	drop test	satisfactory	42	right		satisfactory
18	right		satisfactory	43	30 deg.		satisfactory
19	right	drop test	satisfactory	44	right		satisfactory
20	45 deg.	drop test	satisfactory	45	45 deg.		satisfactory
21	right		satisfactory	46	right		satisfactory
22	45 deg.		satisfactory	47	right		satisfactory
23	right		satisfactory	48	right		satisfactory
24	right		satisfactory	49	right		satisfactory
25	right		satisfactory	50	45 deg.		satisfactory

Table B-2. Reliability test record of the G-7B grabber.

Test No.	Angle	Remarks	Conclusion
1	right	well oiled to start	satisfactory
2	right		satisfactory
3	right		satisfactory
4	right		satisfactory
5	right		satisfactory
6	right	possible improper loading	unsatisfactory
7	right		satisfactory
8	right		satisfactory
9	right		satisfactory
10	45 deg.		satisfactory
11	right	drop test exceeded 45 deg	unsatisfactory
12	right		satisfactory
13	right		satisfactory
14	right		satisfactory
15	right		satisfactory
16	right	drop test	satisfactory
17	right		satisfactory
18	right		satisfactory
19	right	soft tap	satisfactory
20	30 deg.	soft tap	satisfactory
21	right	underwater long drop	satisfactory
22	right	underwater long drop	satisfactory

Table B-3. Reliability test record of the G-7C grabber

Test No.	Angle	Remarks	Conclusion	Test No.	Angle	Remarks	Conclusion
1	right		satisfactory	26	30 deg.		satisfactory
2	right		satisfactory	27	right		satisfactory
3	right		satisfactory	28	right		satisfactory
4	right		satisfactory	29	right		satisfactory
5	45 deg.		satisfactory	30	45 deg.		satisfactory
6	45 deg.		satisfactory	31	right	re-oiled	satisfactory
7	right	drop test	satisfactory	32	30 deg.		satisfactory
8	right	drop test	satisfactory	33	right		satisfactory
9	right	hard hit	satisfactory	34	right	underwater test	satisfactory
10	right	hard hit	satisfactory	35	right	underwater test	satisfactory
11	right		satisfactory	36	right	underwater test	satisfactory
12	right		satisfactory	37	right	underwater test	satisfactory
13	right		satisfactory	38	right	underwater	satisfactory
14	45 deg.		satisfactory	39	right	underwater drop	satisfactory
15	right		satisfactory	40	right	drop test	satisfactory
16	right	drop test	satisfactory	41	right	underwater test	satisfactory
17	right	light press	satisfactory	42	right	underwater longdrop	satisfactory
18	right		satisfactory	43	right	underwater test	satisfactory
19	right		satisfactory	44	right	underwater test	satisfactory
20	right		satisfactory	45	right	underwater drop	satisfactory
21	right		satisfactory	46	right	underwater test	satisfactory
22	right		satisfactory	47	right	underwater test*	satisfactory
23	right		satisfactory	48	right	underwater test*	satisfactory
24	15 deg.		satisfactory	49	right	exceeded 45-deg. longdrop*	unsatisfactory
25	right		satisfactory	50	right	underwater test*	satisfactory

*Underwater test-target flat on bottom.

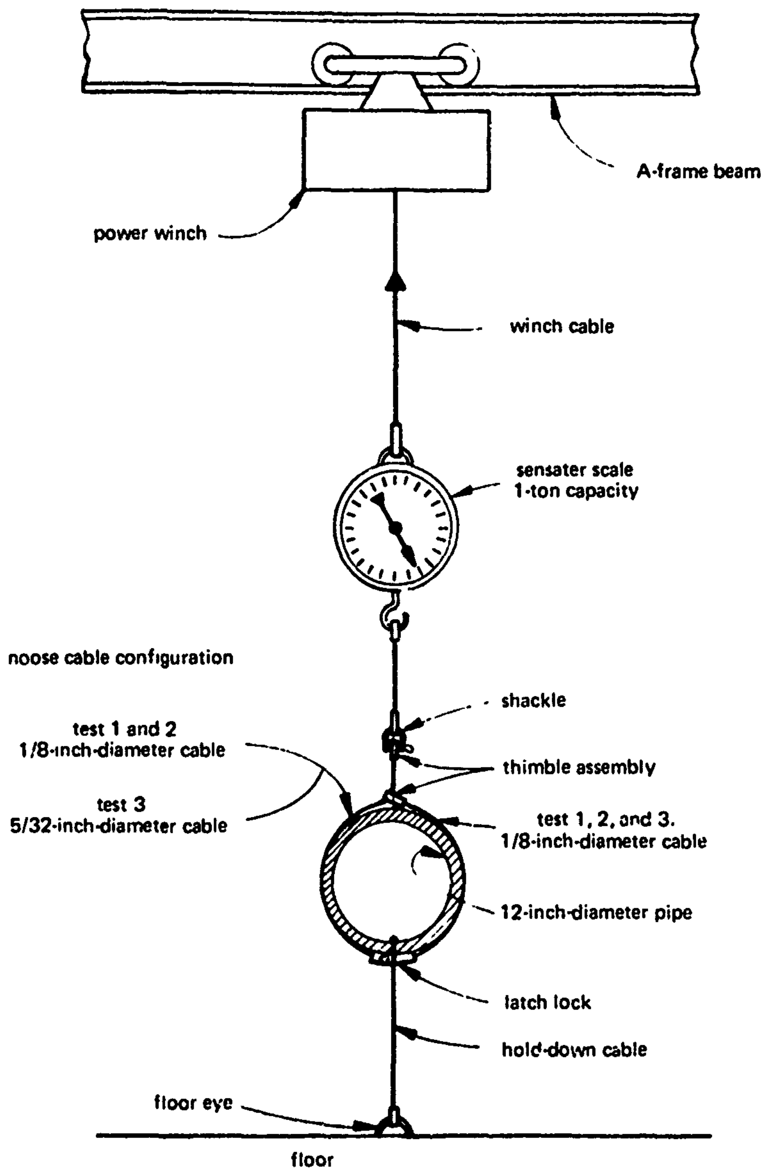


Figure B-1. Lifting cable and latch load test setup for G-7 series grabber.